NASA Scatterometer Near-Real-'J'imc, Value Added Products for Mcso/Synoptic-Scale Marine Forecasting

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Abstract -- The potential for near-real-time NASA Scatterometer (NSCAT) data to contribute to operational marine forecasting is described. A description of the NSCAT Value Added Product (VA]') activity -- an effort to provide near-real-time wind images to the public and operational forecasters -- is presented.

INTRODUCTION

Spaceborne scatterometers arc radar instruments specifically designed 10 measure ocean surface wind speed and direction. This technique was initially demonstrated with the 1978 flight of the Ku-Band Seasat Scatterometer (SASS) [I], and has most recently been demonstrated with the successful operation of the C-band IRS-1 scatterometer [2]. In August of 1996, the Ku-hand NASA Scatterometer (NSCAT) will be launched aboard the Japanese Space Agency Advanced Earth Observation Satellite (ADEOS) [3]. NSCAT will operate for three years and make accurate measurements of ocean surface wind speed and direction in two 600 km swaths on either side of the spacecraft, thus providing a significant expansion and improvement of the current scatterometer data base.

The application of scatterometer data to oceanographic and climatological research is well documented [4]. Ocean wind stress is a primary factor in driving ocean circulation and thus the global energy balance. In addition to its applicability to the. study of wi nd forced ocean circulation and global climate change, scatterometer wind data, made available to users on a sufficiently timely basis, is also of great value in mesoscale and synoplic-scale marine forecasting. It is these "operational" applications of the NSCAT data which arc the focus of this paper.

01'1 ERATIONAL APPLICATIONS

Several potential operational applications of scatterometer data have been noted elsewhere [S]. Below wc include a list of several areas where scatterometer measurements arc likely to have the highest impact.

A. Marine. Hazard Warning: Perhaps the most noteworthy operational application of scatterometer data is determining the location, structure, anti strength of storms at sea. Severe marine storms -- which include tropical cyclones (hurricanes, typhoons} and mid-latitude cyclones -- arc among the most destructive of all natural phenomena. In the United States alone, hurricanes have been responsible for at least 17,000 deaths since 1900, and hundreds of millions of dollars in damage annually. If worldwide statistics arc considered, the numbers arc substantial i y higher. Although typically not as violent as tropical cyclones, severe mid-latitude storms nevertheless exact a heavy toll in casualties and material damage [5]. Cloud imagery from satellites has significantly enhanced the forecasters ability to detect and track storms. Scatterometer data will augment these familiar images by providing a direct measurement of the surface wind to compare to the cloud patterns. Scatterometer data can thus assist in the identification of the storm center locations, storm related fronts, anti the location of the most damaging winds within the storm structure. Scatterometer derived winds can also be used as inputs to models that forecast wave height and flooding.

B. Ocean Ship Routing: Scatterometer observations of winds can be of particular significance to ocean going cargo ships. In today's world of international commerce, billions of dollars worth of food, fuel, raw materials, and manufactured goods arc transported by sca yearly. Besides the benefits derived from the ability of NSCAT to locate anti identify storms which may cause harm to vessels or crew, satellite wind data can also allow sca captains to chart their courses more efficiently. With a knowledge of the winds, the ship master can choose a route to avoid heavy seas or high headwinds which can slow the ship's progress and consume an excessive amount of fuel. Previous to the flight of spaceborne scatterometers, ship captai ns had to rely completely on sporadic anti potentially unreliable reports from other ships, and widely spaced measurements from buoys. A satell itc based instrument allows a much more regular and extensive assessment of the winds. This is particularly advantageous in remote regions of the world where there arc few, i f any, other wind measurements.

C. Drilling and Mining Operations: Oil and gas production has been undertaken at many offshore sites around the world -- the Gulf of Mexico, the North Sea, and the Persian Gulf being prominent examples. I'borough knowledge of the historic wind and wave conditions at a specific location arc important to the appropriate design of dri lling plat fores. Accurate knowledge of the current sca state as well as warnings of impending storms arc critical to safe and efficient drilling operations. In the event of an oil spill, the surface wind is a key factor in determining how the oil will spread, Wind data from NSCAT can thus be used by clean-up and containment crews to minimize the environmental impact of such a disaster.

NSCAT SYSTEM

The NASA Scatterometer (NSCAT) is scheduled for launch aboard the Japanese Advanced Earth Observing Satellite (ADEOS) in August 1996. The NSCAT instrument is a Ku-band radar which measures global ocean surface wind speeds and directions at up to 25 km resolution. The wind measurement is accomplished by first measuring the normalized backscatter cross section (σ_0) of the ocean at three different azimuth angles and two different polarizations using eight fan-beam antennas. Wind vectors are then retrieved during ground data processing using an empirical geophysical model function which relates σ_0 to wind speed and direction.

The NSCAT system offers several enhancements over previous scatterometers. With respect to SASS, which measured backscatter cross section at two azimuth angles on either side of the spacecraft, NSCAT makes additional measurements at a third azimuth angle. This has been demonstrated, both in analyses and with the ERS-1 experience, to greatly enhance the ability of ground processing to remove wind direction ambiguities which are inherent to the wind retrieval process [3]. Because NSCAT has two 600 km swaths on either side of the. spacecraft, the overall ocean coverage will be enhanced relative to the ERS-1 and ERS-2 systems. NSCAT will cover approximately 77% of the worlds oceans in 24 hours, and 95% in 48 hours. This will be a particular advantage to operational users, for whom measurement coverage and revisit lime is extremely important in order to follow fas(-developing meteorological phenomena.

The main NSCAT science data stream will be sent from Japan, and processed 10 winds by the Science Data Processing System within two weeks. The science data stream will be calibrated anti Earth located to a very high accuracy. The NSCAT science data will be distributed to researchers via the Physical Ocean Distributed Active Archive Center (PODAAC).

NEAR REAL-TIME PROCESSING

Although the main science data stream has the high accuracy necessary for research purposes, it is not available on a sufficiently timely basis for use by operational users. To allow near real-ti me access by operational users, NOAA, in coordination with NASA anti JPL, has invested in a satellite data downlink and wind processing i nfrastructure that will allow access to scatterometer wind measurements within 2-4 hours after data take.

As the first element of the near rcai-time processing system, the scatterometer data wiii be downlinked directly from ADEOS to NASA ground receiving stations at Wallops Island, Virginia, and at the Alaska SAR facility in Fairbanks, Alaska. Each downlink pass over these stations will playback lilt most recently acquired NSCAT data.

From the ground receiving stations, the data will be transmitted to NOAA in Suitland, Maryland for wind processing. For this step, JPL has developed a special version of the NSCAT wind processor which is able. to generate wind estimates from the raw data in near real-time -- ten minutes of processing for each orbit's worth of NSCAT data. Although the radiometric and Earth location accuracy is not to the high research standards of the main science product, the near rcai-time product generated by NOAA is judged to be of sufficient accuracy for operational users where the timeliness of the data is all important. The NOAA scatterometer data will be provided to the National Meteorological Center (NMC) for the development of improved numerical forecasts, the National Hurricane Center for the study of severe tropical storms, and other domestic anti international operational weather organizations.

VALUE ADDED PRODUCTS

As an additional effort to foster the utilization of scatterometer data by tile pub] ic and the operat ional meteorological communit y, the NSCAT project at JPL has initiated the Value Added Product (VAP) activity. The VAP activity, working very closely with the larger NOAA near real-time effort, will also receive anti process the NSCAT data in near rcai-time. A "value adcicd" step will then be performed to create images to be made available to the public via the Internet. The goal of the valued added images is to display the wind data in a visually informative way, and provide a convenient means of access by commercial and educational users.

One important element of the val uc added processing is the co-registration of NSCAT wind data with geosynchronous cloud imagery. Such a visual correlation will add additional in formation to traditional cloud images. For instance, hurricanes begin their lives as rather ill-defined masses of clouds in the Eastern tropical Atlantic. The addition of scatterometer wind data to these images wili clearly identify features where strong cyclonic circulation has begun to form.

Another value added step to be performed is the interpolation of NSCAT data between swaths. Successive NSCAT orbits do not touch each other at the equator or mid-latitudes, and thus produce gaps in cove.rage for short time periods. Furthermore, a 400 km "nadir gap" exists in the center of the swath about the ADEOS orbit track. To allow users to view a continuous near real-time wind field, it is necessary to invoke a two dimensional spatial interpolation scheme. The interpolation technique must match the "true" data within the swath with a minimum of smoothing, while providing a reasonably accurate estimate of the "missing" data. To accomplish this, an interpolation scheme based on the objective analysis approach will be employed [6]. Taking advantage of